PRELIMINARY

DATA SET 407

INTERFACE

SPECIFICATION

JUNE 1975

MANAGER — DATA SYSTEMS & OPERATIONS

326-456

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DATA STATION 407-TYPE

Composed of

1. Cabinet
2. Data Mounting (D/M)
3. Data Set (D/S) 407-type

Identification	Max. Number D/S	Dimensions (in Inches) W	H	D	Max. Number D/M
KS-20018-L12A	8	24	17	19	1
KS-20018-L11A	24 (407A)	24	30	19	3 (407A)
	16 (407B)				2 (407B)

Power Requirement

AC 117 volts ± 10%, 60 Hz ± 5%
Each group of eight sets consumes about 100 watts of AC power

Environmental Requirement

Ambient Temperature
Range: 40° to 120°F
Relative Humidity: 20% to 95% at 75°F

DATA SET 407-TYPE

Dimensions (in inches)
W-1.45 H-8 D-12.1

CHARACTERISTICS

Type Unit: TOUCH-TONE® receiver for multiple data
                        set installations

Type Transmission: Multifrequency two-out-of-eight parallel

Interface: (1) EIA (2) Contact equivalent

Rate: Up to ten char./sec. nonsynchronous

Clocking: None provided

Line Facility: Switched message network (DDD) Basic 2001-
                        type channel-private line alternate voice/
                        data. Basic 3002-type channel-private line
                        alternate data/voice.

Operation:	Half-duplex - 2-wire
	Full-duplex - 2-wire
Works with:	TOUCH-TONE telephones or pads, TRANSACTION* telephones, or other TOUCH-TONE signaling devices
Unattended Answer:	Yes
Answerback:	Tone frequency of 2025 Hz. Voice transmit level requirements -7 to 0 dBm.

Operating Frequencies:

Group A	Group B
697	1209
770	1336
852	1477
941	1633

INTERFACE

Connector:	25-pin Cinch-or Cannon-Type DB-19604-432 Connector with Cinch DB-51226-1 Hood (or equivalents) or with Cinch DB-239-13-99-140 Hood (or equivalent) if the cable bending radius is greater than 1.125 inches.

Circuit Function:

Data Set Ready Indication:	Turn ON approximately three seconds after ringing is tripped. Turn OFF approximately 50 msec. after Data Terminal Ready goes OFF to disconnect the set.
Data Lead Indication:	42 ± 1 msec. pulse on two-out-of-eight Data leads.
Data Present Indication:	Turn ON 2 to 3 msec. after Data leads turn ON. Turn OFF when Data leads turn OFF or until valid TOUCH-TONE character ends, whichever occurs last.

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*Trademark of AT&T

Preface

This Technical Reference is a reissue of PUB41408, Issue 1, Data Set 407A Interface Specifications. It is reissued to include both the 407A and 407B data sets.

DATA SET 407-TYPE INTERFACE SPECIFICATIONS

1. General

The 407-type data station consists of multifrequency receivers intended to be used for the reception of TOUCH-TONE signals at a rate of up to ten char./sec over the switched telephone network or over basic (unconditioned) private lines. The data sets may receive information from TOUCH-TONE telephone sets,* TOUCH-TONE pads, Bell System 401-type data set transmitters operating in the numeric mode, the Bell System TRANSACTION† telephone, or equivalent signal sources. The 407-type data set is designed primarily for multiline installations. It is

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* Some of these may require "polarity guards" for data transmission.

† Trademark of AT&T.

equipped with a parallel, two-out-of-eight interface having electrical characteristics which conform to the Electronic Industries Association (EIA) standard for voltage interfaces. The 407-type data set is also available with a contact-equivalent interface. Special interfaces available on the 403 data set, including the Binary Coded Matrix (BCM) interface and the serial, start-stop ASCII interface are not available with the 407-type data stations. However, certain other features, such as the ability to detect TOUCH-TONE signals in the midst of outgoing signals are provided.

The 407, like its predecessor the Bell System 403, has protection against echoes and against digit simulation from voice and noise entering the system through the telephone handset. Hence, either the 407 or the 403 should be used to receive signals from TOUCH-TONE telephones, rather than the Bell System 401J data set receiver. Although the 401J receiver has the ability to detect TOUCH-TONE signals, it does not have protection against echoes and digit simulation. The 401J depends on rest tones to protect against echoes in the telephone plant, and the TOUCH-TONE telephone does not transmit rest tones. Similarly, 407-type data sets should be used to

receive signals from the TRANSACTION telephone, because
it too, does not transmit rest tones, and the answer tone
signal (see Section 2.3.3) from the 403 is not of sufficient
duration to guarantee proper operation of the TRANSACTION
telephone.

The 407-type data station can contain either 407A
or 407B data sets. The 407B data set combines all the
features of the 407A with additional circuitry adding new
features. These new features are compatible with the
operation of sophisticated terminals, such as the
TRANSACTION telephone. Although the TRANSACTION telephone
will operate with both the 407A and 407B, using the 407B
allows using some features of the TRANSACTION telephone
which are unavailable using the 407A.

1.1 Physical_Description

Figure 1 shows a 407-type data station that
consists of a cabinet containing twenty-four 407A data
sets. Because of ventilation requirements, a similar
cabinet containing 407B data sets would contain 16 sets.
Another cabinet is available for up to eight 407A or 407B
data sets (width 24 inches, height 17 inches and depth 19
inches). The data sets are arranged in "nests" of up to
eight data sets each. Each nest is served by a single

power supply, and each cabinet is served by a single test unit. In the figure, the top nest contains a test unit and a power supply, the lower nests each contain only a power supply. Each station equipped with either 407A or 407B data sets is capable of operating in a room ambient temperature between 40° and 120°F. The 407-type data set will operate over a relative humidity range of 20 to 95 percent at 75°F and 20 to 40 percent at 120°F. Each separate 407A data set weighs approximately 2-3/4 pounds, and the fully equipped 24-set cabinet weighs approximately 227 pounds. The 407B data set weighs approximately 3 pounds, and the fully equipped 16-set cabinet weighs approximately 168 pounds.

1.2 Power and Grounding Requirements

Electric power is fed to the 407-type data station from a customer-provided 117 volt ±10 percent, 60 Hz ±5 percent nonswitched source by means of a three-prong plug. One 10-foot AC power cord is provided with each 41A-type data mounting. In a multiple data mounting cabinet, AC power is multipled from nest to nest via the 6-foot power cord provided with the 41B-type data mounting. Each nest of eight 407A data sets consumes approximately 105 watts of AC power; each nest of 407Bs consumes approximately 115

watts. If fewer then eight sets are used in the nest, the power consumption is reduced, but not linearly. For instance, four 407A data sets consume 60 watts of AC power and just one 407A consumes 28 watts of AC power at a 117-volt line voltage.

Protective ground is provided via the ground wire of the power cords. A signal ground is provided to the customer for use as a signal level reference point. Means are provided in each nest for optional disconnection of signal ground from frame ground. If signal ground remains unconnected to frame ground, signal ground reference between nests must be provided by external wiring.

1.3 Location of Data Station

In accordance with the recommendations of EIA standard RS-232-C, the 407-type data station should be located so that the customer-provided interface cord to the data terminal does not exceed 50 feet in length.

1.4 Lamp Indications

Each data set has seven lamps that indicate the status of six interface leads and whether the 5-volt DC power is on or off. The lamps are on when the corresponding interface circuit is in an ON condition. The circuits with lamp indications are as follows: Data Terminal Ready

(lamp designation is TR - Terminal Ready), Ring Indicator

(RI), Data Set Ready (lamp designation is MR - Modem Ready),

Data Present (DP), Attendant Request (AR), and Out of

Service (OS). See Section 3 for a description of these

functions. In addition, the test set has two lamps that

indicate when the local or the remote test is in progress,

as well as a set of lamps which indicate the row and column

of received characters during a test.

1.5 Features Common to All 407-type Data Sets

The 407A and 407B share a number of features

designed to facilitate the operation of TOUCH-TONE data

systems. The 407-type data set provides a full-time remote

control capability. This capability allows the 407 to

receive and decode TOUCH-TONE data in the presence of

locally generated voice signals. However, depending on

the line balance and the strength of the locally generated

signal, the sensitivity of the 407 to the TOUCH-TONE signals

is reduced. (See Section 2.2)

The 407 is fully compatible with Automatic Call

Distributor (ACD) operation and can be incorporated into

systems utilizing either the Bell System 2B or 3A ACD.

Other features provided with the 407-type data

set include both local and remote testing (described in

Section 6), and a number of customer options (described
in Section 1.7).

1.6 New Features of the 407B Data Set

The 407B data set provides several new features
designed to allow it to be compatible with sophisticated
terminals such as the Bell System TRANSACTION telephone.
These features include enabling the system to remain in
operation when the computer is "down," allowing referral
at the initiation of the remote terminal user (hereinafter
called "Terminal Initiated Referral (TIR)"), an optional
arrangement allowing control of the out of service function
by the DTR (Data Terminal Ready) interface lead, and
responding to a hang-up code transmitted from the distant
terminal.

1.6.1 "Computer Down" Operation

When the computer is unavailable, it is desirable
in certain systems to answer calls and notify the calling
party that the computer is unavailable. For instance,
consider a credit verification system in which all
transactions are checked, regardless of amount. When the
computer is unavailable, it may be desirable to handle
transactions below a floor limit in some routine manner,
such as using a list of known bad accounts periodically

distributed to all system users. On the other hand, transactions above the floor limit may require verification using up to the minute information available only at the data center. Accordingly, when the computer is down (see Section 1.8.1 for a description of the methods of detection of computer-down) the 407B will answer all incoming calls and respond with a 3.5 second ± 25 percent answer tone (in contrast to the normal 1.5 second ± 25 percent answer tone). Some remote terminals, such as the Bell System's TRANSACTION telephone can detect this extended answer tone and determine if the call should be referred to an attendant at the data center. If so, the Terminal Initiated Referral signal (see Section 1.6.2) is sent to the 407B. Users of unsophisticated terminals, such as the TOUCH-TONE telephone may not be able to distinguish between the extended and normal answer tone signals. To account for this, the 407B reacts to receipt of the first character which is not a "*" $(A_4 B_1)$. If that character is not in the B_4 column of Figure 2, as will be the case if the user of a TOUCH-TONE telephone begins to enter data, the 407B will send answer tone in an ON-OFF cycle at a .5 Hz rate to notify the user that the computer is unavailable. The user may then

terminate the call or request a referral by sending the
Terminal Initiated Referral signal.

During "computer down" operation, interface signals
from the business machine are monitored solely by the
"computer down" detection circuitry. Depending upon the
selected method of detection, this circuitry monitors the
state of a switch contact, all DTR (Data Terminal Ready)
leads, or both the switch contact and all DTR leads.
Except for this, all interface control leads from the
business machine are ignored during "computer down"
operation.

After transmitting the initial long answer tone,
the 407B will begin a time-out. If the Terminal Initiated
Referral (TIR) signal is not received within 15 seconds
after the answer tone ends, the 407B will disconnect the
call.

1.6.2 Terminal Initiated Referral

The 407B will respond to a special TOUCH-TONE
code ("**", or A_4B_1-A_4B_1) by executing a referral. The
means of referral differ with the type of referral equipment
used (CALL DIRECTOR or Automatic Call Distributor) and
are described fully for both types in Sections 4.1 and
4.2. The Terminal Initiated Referral feature exists

whenever the "computer down" mode is in effect. As an

option, it can be extended to be in effect at all times.

This allows a remote terminal user to request a referral

when the user has trouble or questions concerning a

transaction. The computer can recognize the special code

and be ready to communicate with the referral clerk.

1.6.3 Out of Service Controlled by Data Terminal Ready

This feature, which has been included to facilitate

operation with the "computer down" circuitry of the 407B,

allows the Out of Service signal to the serving central

office to be controlled by either of two interface leads,

Data Terminal Ready (DTR) or Out of Service (OS). When

the Out of Service signal to the serving central office

is controlled by the OS lead at the business machine

interface, DTR may be operated independent of Out of Service

considerations. For example, the business machine may

hold the DTR interface lead in the OFF state when idle and

respond to Ring Indicator by turning DTR ON.

If DTR control of OS is selected, the business

machine may busy out a line by turning DTR OFF. When this

option is used in conjunction with "computer down" detection

by means of all DTR OFF (see Section 1.8.1), the business

machine may busy out ports as trouble is encountered. If

all ports are brought out of service, all DTRs will be OFF
and the data station will enter the "computer down" mode
(see Section 1.6.1).

1.6.4 Hang-up Code

Data set 407B will respond to the TOUCH-TONE input
sequence "*#*" (A_4B_1-A_4B_3-A_4B_1) by momentarily turning OFF
the Data Terminal Ready (DTR) logic, regardless of the
state of the DTR lead at the customer interface. This
causes the data set to terminate the call. Consequently,
if the calling terminal transmits the "*#*" sequence just
prior to disconnecting, the 407B data set will respond by
immediately returning to the on-hook state. This feature
eliminates the delay required to determine that the far
end has disconnected by means of the activity timer
typically used by the business machine. It should be
noted, however, that provision of this feature does not
eliminate the need for an activity timer because of the
possibility of error situations in which the disconnect
sequence is not received (calling party has reached wrong
number, etc.).

1.7 Customer uptions Available with All 407-type Data Sets

1.7.1 Voltage- or Closure-type Interface

The 407-type data set is designed to work with voltage drivers and terminators that have electrical characteristics as specified in EIA Standard RS-232-C. However, if the customer terminal is equipped with a contact closure interface, the 407 interface can be modified, by means of options activated at installation, to simulate a contact interface. The customer terminal must be able to accept the voltage signals from the data set drivers and to provide signals compatible with the data set terminators as specified in Section 5.2.

1.7.2 DDD or Private Line Service

The 407 can operate over the Direct Distance Dialing (DDD) network or over basic (unconditioned) Private Lines. An installer-activated option provides for the type of operation to be used in the customer's system.

1.7.3 Referral Using CALL DIRECTORs or Automatic Call Distributors (ACDs)

The 407 data set is compatible with referral schemes utilizing either a CALL DIRECTOR or a 2B or 3A Automatic Call Distributor (ACD). When a CALL DIRECTOR arrangement is used, a single 407 data set serves one

incoming line, and referral switching is done in the data
set. Where an ACD is used, a single 407 can serve more
than one line, due to call concentration and queueing in
the ACD. Referral switching is done in this case by the
ACD. A complete description cf the operation of the 407
with both of these referral arrangements is described in
Sections 4.1 and 4.2.

1.8 Options Available Cnly on 407B

1.8.1 Detection of "Computer Down"

At the option of the customer, the 407B can be
configured to detect the fact that the computer is down
in one of three ways or not at all. The first way is via
a single switch closure which places all 407Bs in a station
in the "computer down" mode. In addition, the data set
can go into the computer down mode when all of the DTR
leads in the data station have been simultaneously turned
OFF indicating that no calls are in progress and no ports
are ready to answer calls. If this method is used, the
option of controlling Out of Service (see Section 1.8.3)
with DTR has the feature that each set can be put out of
service as trouble is encountered and, if all the data
sets are out of service, the computer down mode will
automatically be entered. The final method of detection

of computer down is the OR combination of the switch closure
and the "all DTRs OFF" condition. The selection is
activated at installaticn.

1.8.2 Terminal Initiated Referral - Always or During
"Computer Down" Only

The Terminal Initiated Referral (TIR) feature
described in Section 1.6.2 can be optioned in one of two
ways. The feature can be active always or only during
computer down intervals. The selection is activated at
installation.

1.8.3 Out of Service Controlled by DTR or OS

This option, described in Section 1.6.3 causes
the Out of Service indication to be the complement of the
Data Terminal Ready indication. If the option is not
selected, the Out of Service indication is controlled by
the OS lead. The selection is activated at installation.

1.9 Option Summary

Following is an cption table summarizing all of
the 407 data set options available to the customer.

Option	Description	Explanation
A	DDD	Type of Operation
B	Private Line	
C	No ACD used	Referral Switching
D	ACD used	provided by ACD
H	EIA	Type of Interface
J	Contact Equivalent	
K*	TIR-Always	
L*	TIR-During Comp Down Only	Terminal Initiated Referral
M*	Out of Service controlled by OS	Out of Service control
N*	Out of Service controlled by DIR	

2. TOUCH-TONE Systems

The 407-type data station, when used with TOUCH-TONE telephones, provides a low-speed, two-out-of-eight, parallel data transmission system for use in DATA-PHONE service. When the 407B data set is used with the Bell System TRANSACTION telephone, and optionally with associated referral equipment [CALL DIRECTOR or Automatic Call Distributor (ACD)], it forms the Bell System Switched Network TRANSACTION Telephone System.

The frequency plan of the audio-frequency tones utilized in TOUCH-TONE service is shown in Figure 2. Eight frequencies are employed, and these are arranged in two

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* Available on 407B only.

groups of four - a low group and a high group. A character
or a digit is represented by two frequencies, one from
each group. This yields 16 possible characters. The
selection of the eight frequencies was based on many
factors; among the most important of these factors were
the transmission characteristics of a typical telephone
line, avoidance of certain combinations of frequencies
that occur frequently in speech, and the selection of
frequencies not harmonically related.

2.1 Transmitters

The 407 data set will operate with the TOUCH-TONE
telephone, the TRANSACTION telephone or any tone transmitter
used with a Bell System protective coupler, which meets
the signal requirements defined in Section 2.1.3. In
addition, the 407B data set can be used to provide certain
features, described in Section 1.6, which are unavailable
in the 407A.

2.1.1 The TOUCH-TONE Telephone

At present, only 12 of the 16 possible combinations
of TOUCH-TONE frequencies are used on standard TOUCH-TONE
telephone sets, and these represent the ten numerals (0
through 9) along with the symbols * (asterisk) and # (number
sign). Some TOUCH-TONE telephones use only ten

combinations, omitting the * and #. The arrangement of the 12 buttons is shown in Figure 2. The other four combinations are presently unassigned for standard telephone service.

2.1.2 The TRANSACTION Telephone

The TRANSACTION telephone is a telephone augmented by special features which increase its utility in Digital Inquiry - Voice Answer-back systems. It transmits the 16 TOUCH-TONE frequencies at a data rate of 8.8 characters per second. It can transmit to both the 407A and 407B data sets; however, a number of its features are not used in a system with the 407A, and therefore, the 407B is the recommended receiver for the TRANSACTION telephone system. For a complete discussion of the TRANSACTION telephone system, including the operation of the TRANSACTION telephone in conjunction with the 407B data set, refer to Bell System Technical Reference, PUB 41804, entitled "Switched Network TRANSACTION Telephone System."

2.1.3 Customer Provided Transmitters

If the customer chooses to provide a tone transmitter to be used with a Bell System protective coupler, the tone signals must meet the following requirements to be compatible with the remote 407 data set:

1. The tone frequencies shall be within ± 1.5 percent of their nominal assigned frequencies.

2. The total power of all extraneous signal components shall be at least 20 dB below the combined tone signal power in the voiceband above 500 Hz.

3. If the tone source is a customer-provided telephone used in conjunction with a data coupler, voice signals shall be suppressed at least 45 dB during tone signal transmission (the telephone transmitter shall be muted). In the case of automatic dialing, it is essential that the suppression be maintained until dialing is completed.

4. Each of the two tones shall attain at least 90 percent of full amplitude within five milliseconds, and preferably within three or less milliseconds for automatic dialers, from the time the signal begins.

5. The following specifications shall apply to the signaling rate:

Minimum duration of 2-frequency signal:

50 milliseconds

Minimum interdigital time: 45 milliseconds

Minimum cycle time (tone-on plus tone-off):

100 milliseconds

6. The tone leak cr nonsignal level shall be less than -55 dBm.

7. Peak transient voltages accompanying the tone signal shall be no greater than 12dB above the zero-to-peak voltage of the composite 2-frequency signal.

8. The 3-second average power of the signal pulses (two tones) shall not exceed the value specified on the protective coupler, and the level of each tone shall not be lower than 5 dB below the specified value. To ensure proper detection, it is further

required that not more than 4 dB difference exist
between the levels of the high and the low
frequencies.

2.2   The Receiver-Data Set 407-Type

The 407 data set is equipped to receive any one
of the 16 possible TOUCH-TONE characters. When a character
is received, two of the eight data leads (one in each of
the two groups of four) go into the marking or "ONE" state
to indicate the presence of that character to the data
terminal. For a definition of the "ONE" and "ZERO" states,
See Section 5.1 and 5.2. Thus, the data bits representing
each character are presented to the customer's terminal
in parallel on a two-out-of-eight basis.

Besides detecting the data signals, the 407 data
set also permits TOUCH-TONE detection in the presence of
answer-back signals. Depending on the line balance and
impedance match and the answer-back signal level, however,
the sensitivity of the receiver is reduced during answer-
back signals. With speech as the answer-back signal, the
intersyllabic intervals have been found to be of sufficient
duration that characters of 100 msec or more duration can
still be effectively received, without loss of sensitivity.

In addition, the 407 data set has a "2-way voice" capability. This is implemented as shown in Figure 3. By placing the Data Receive interface lead in the ON state, both the receive and the answer-back circuits are active simultaneously, and voice or data signals from the remote transmitter can reach the data terminal while answer-back is in progress. If the business machine places the Data Receive lead in the OFF condition, the TOUCH-TONE receiver is removed from the line and essentially a 2-way voice channel exists between the business machine and the remote location.

In addition to the voice answer-back, the data set can generate a 2025 Hz tone upon command from the data terminal. The voice answer-back leads are disabled while this tone answer-back is in progress. The 2025 Hz tone is also used by the data set to provide a recognition signal when answering an incoming call.

2.3 Typical Systems

Two typical systems are described in this section. The choice of referral equipment described in each of these systems is arbitrary and has no bearing on the choice of transmitting terminals. The two types of referral equipment

can function with any compatible type of transmitting
terminals.

2.3.1 TOUCH-TONE Telephone System

One example of the use of the 407 is the credit
check system depicted in Figure 4a. In this system,
inquiries are made about the status of accounts by keying
information into a processor from a remote location by
means of a TOUCH-TONE phone and receiving audio responses
from the processor location.

The Automatic Call Distributor (Bell System 2B-
or 3A-ACD) acts as a line concentrator and a call
controller. When the ACD receives a call, it searches for
a port (data set) that is ready to accept a call and
transfers the call to that line. The data set then converts
the TOUCH-TONE signals sent by the remote terminal into
"ONEs" appearing on the proper data interface leads; the
processor can now recognize the characters and process the
data. Depending on the state of the account, the processor
initiates the proper response in the Audio Response Unit
and the remote terminal receives the audio information.
If the remote terminal sends the hang-up code, the 407B
(if used) will terminate the call at the data base.

If the processor cannot handle the inquiry due to some irregularity in the account or in the data, it can signal the ACD through the 407 that an attendant is needed. Alternatively, with the 407B only, if the remote terminal user desires referral, and the Terminal Initiated Referral (TIR)-Always option is selected, the user can transmit the TIR signal (**), causing the 407B to signal the ACD to link a referral clerk's line to the connection. In either case, when the ACD finds a nonbusy referral clerk's line, it makes the connection and, at the same time, indicates to the processor which referral clerk has been selected by means of a 2-digit TOUCH-TONE code. The computer can then display the account information on that clerk's CRT. The clerk can then discuss the account with the caller while referring to the information on the CRT.

It should be noted that the Bell System ACD does not automatically drop the connection to the business machine through the data set when a referral clerk is summoned, but rather bridges the clerk's line onto the original connection. The business machine can then disconnect the data set from the call (turn DTR OFF) to make it available for other calls or it can stay on-line, so that further data can be inputted during or after the

conversation with the clerk. In the latter case, data can be entered from a TOUCH-TONE set at the remote location or at the referral clerk's location.

If the computer is down when the call comes in, and the 407B data set is used, the call will be answered and an extended (3.5-second) answer tone will be transmitted. If the user does not recognize the extended answer tone as such, and begins to key data, the 407B will transmit the answer tone in a beeping fashion to notify the user that the computer is down. The user then has the option of requesting a referral (by keying **) or, alternatively, of consulting instructions provided for him by the data base.

2.3.2 TRANSACTION Telephone System

Another example of the use of 407 data set in a data system is shown in Figure 4b. The transmitters in this case are TRANSACTICN telephone sets. The receivers are 407B data sets. The referral equipment in this example is a multiposition CALL DIRECTOR arrangement.

The TRANSACTION telephone, a sophisticated telephone capable of reading data encoded on a magnetic stripe affixed to a plastic card (e.g., a credit card), automatically dials the data base telephone number, and

buffers the information to be transmitted. When the call

reaches a 407B data set, the data set answers the call and

sends a 1.5-second burst of 2025 Hz answer tone. The

answer tone triggers the transmission of the data buffered

by the TRANSACTION telephone. The data is presented to

the business machine in two-out-of-eight format. The

processor can give the proper audio response via the ARU

and the voice port.

If the processor cannot handle the call for any

reason, it signals the 407B via the AR lead (see Section 3).

Alternatively, if the Terminal Initiated Referral-Always

option has been selected, the terminal user can press the

ATTN button to initiate a referral. The 407B flashes a

light on the CALL DIRECTORs corresponding to the line on

which the call requiring assistance came in. A clerk

responds to the flashing light by depressing the associated

key and lifting the handset to answer the referral request

and handle the problem. The data set will remain on-line

in this mode (called the TALK mode), but will be unable

to receive data so long as the clerk is off-hook. If the

clerk returns the call to the DATA mode by depressing the

DATA (HOLD) button, data can again be sent.

If the computer is down when the call comes in, the 407B will answer the call and send a 3.5-second answer tone instead of the normal 1.5-second answer tone. The TRANSACTION telephone will recognize this tone and take appropriate action by either notifying the user to follow special instructions furnished by the data center or referring the call, depending upon the transaction particulars.

For an exhaustive description of the interface signals in the referral configurations described in this section and the previous one, refer to Section 4.

3. Interface

The 407A and 407B data sets provide an interface (shown in Figure 5) that either conforms to the electrical characteristics of EIA standard RS-232-C or can be adapted for use with a closure interface by means of an option (see Section 5.2). A 25-pin connector that provides an interface similar to the Bell System Data Set 403 (but leads 19 and 21 have different functions - see below) is employed for connection to the business machine. The business machine manufacturers must supply a cable with a matching plug and hood. The basic connector shall be a Cinch DB-19604-432, or equivalent, terminated on a 25-

conductor cable. If the cable used has a 1.125-inch maximum
bending radius, such as that obtainable from Alpha Wire
Company 1181/25-22 AWG, then a Cinch DB-51226-1 straight
molded hood may be used. If the cable has a larger bending
radius, a right-angle hood, Cinch 239-13-99-140 or its
equivalent, must be used. Cables with a bending radius
greater than 4 inches are not recommended. A summary of
the interface leads is given below and is followed by a
detailed description of each of the circuit functions.

INTERFACE SUMMARY

Pin No.	Designation	Discussed in Paragraph
1	Frame Ground (FG)	a
2	Voice Receive A (VRA)	b
3	Data A_1	c
4	Data A_2	c
5	Data A_3	c
6	Data A_4	c
7	Not Used	d
8	Voice Receive B (VRB)	b
9	Data B_1	c
10	Data B_2	c
11	Data B_3	c
12	Data B_4	c
13	Not Used	d

14	Ring Indicator (RI)	e
15	Attendant Request (AR)	f
16	Data Present (DP)	g
17	Voice Answer-back A (VAA)	h
18	Voice Answer-back B (VAB)	h
19	DATA Mode (DM)	i
20	Tone Answer-Back (TAB)	j
21	Data Receive (DR)	k
22	Data Terminal Ready (DTR)	l
23	Data Set Ready (DSR)	m
24	Signal Ground (SG)	n
25	Out of Service (OS)	o

a. Frame Ground, Lead 1: This conductor is electrically bonded to the data set frame. It is further connected to external grounds through the power cord. This should be the same ground as used for Frame Ground by the business machine.

b. Voice Receive, Leads 2 and 8 - From Data Set to Business Machine: These two leads provide a 600-ohm balanced pair on which the line signals are passed to the customer. These signals are passed through a buffer circuit without attenuation or amplification, before being passed to the interface.

c. Data, Leads 3-6, 9-12 - From Data Set to Business
    Machine: The data set places the data leads in the
    MARKING (ONE) state for a period of 42 $\pm$1
    milliseconds upon receipt of a character. This
    marking condition of the data leads will start 2
    to 3 milliseconds prior to the appearance of a "ONE"
    (mark) on the Data Present lead (16).

d. Leads 7 and 13 are not used in 407 data set.

e. Ring Indicator, Lead 14 - From Data Set to Business
    Machine: An ON condition on this circuit indicates
    that ringing signal is being received. The ON
    condition approximately coincides with the
    application of the ringing signal.

f. Attendant Request, Lead 15 - From Business Machine
    to Data Set: When a key telephone is employed, an
    ON condition of the Attendant Request lead while
    the data set is in the DATA mode will cause the
    lamp associated with the line to flash at a 1 Hz
    rate. No audible indication is given.
    When an ACD is employed, an ON condition of the
    Attendant Request lead will cause the ACD to hunt
    for a referral clerk's line that is not in use,
    indicate to the business machine which line was

chosen, and signal (usually by ringing) the clerk
to pick up the line. If no clerk is available, the
AR lead must be turned OFF and back ON (See Section
4.2). It should be cycled OFF and ON until a nonbusy
line is found, at which time it should be turned
OFF. (See Section 4.2)

g. Data Present, Lead 16 - From Data Set to Business
Machine: A ONE on this lead indicates that the
data set is receiving a valid TOUCH-TONE signal.
The ONE condition is presented 2 to 3 milliseconds
subsequent to signals on the Data leads and will
be maintained until the Data leads are placed in
the SPACING (ZERO) state or until there is a loss
of suitable input signal from the communication
line, whichever occurs last.

h. Voice Answer-Back, Leads 17 and 18 - From Business
Machine to Data Set: The Voice Answer-Back leads
are terminated within the data set in a 600-ohm
balanced-to-ground transformer. Voice signals
should be delivered from the customer's equipment
at -7 to 0 dBm. Tone signals should be delivered
from the customers equipment at -1 dBm $\pm$1 dB. An
internal limiter will clip any peaks above +3 dBm.

Any direct current present must be less than 5

milliamperes. The impedance of the customer's

equipment furnishing the voice signals should be

balanced with respect to ground, to prevent unwanted

noise transmission. The out of band power should

meet the following specifications:

3995 - 4005 Hz	< - 19 dBm
4006 - 10000 Hz	< - 16 dBm
10000 - 25000	< - 24 dBm
25 kHz - 40 kHz	< - 36 dBm
> 40 kHz	< - 50 dBm

i. DATA Mode, Lead 19 - From Data Set to Business

Machine: An ON condition of this lead indicates

that the data set is in the DATA mode. An ON

condition can occur only in conjunction with an ON

condition of DSR (see paragraph m). An OFF condition

of the Data mode (DM) lead in conjunction with an

ON condition of DSR indicates that the set is in

the TALK mode. DM and DSR initially come ON together

3 seconds after ringing is tripped, but if there

is a transfer to the TALK mode and then a return

to the DATA mode, there is another delay of 3 seconds

before DM comes back ON. Note that there is no

"TALK" mode when an ACD is employed, and DM will function the same as DSR in this case.

j. Tone Answer-Back, Lead 20 - From Business Machine to Data Set: An ON condition of this lead will cause the data set to disable the Voice Answer-Back Port and to generate an answer-back tone of 2025 Hz. The customer can use this lead to transmit data by ON-OFF keying at a low rate if his receiver is capable of detecting it.

k. Data Receive, Lead 21 - From Business Machine to Data Set: The business machine must place the Data Receive lead in the ON state to connect the TOUCH-TONE receiver to the line. This permits the reception of data. If it is desired to remove the TOUCH-TONE receiver from the communications channel, the business machine may place the Data Receive lead in the OFF state. Transmission of answer-back signals is not dependent on the state of this lead, as it is in the 403 series of data sets.

l. Data Terminal Ready, Lead 22 - From Business Machine to Data Set: The business machine must place the Data Terminal Ready lead in the ON state to prepare the data set to be connected to the communications

line and to maintain connection to the line once
it is established. Placing the Data Terminal Ready
lead in the OFF state will cause the data set to
be removed from the communications channel. An OFF
condition of at least 50 (100 with an ACD)
milliseconds, or until Data Set Ready goes into the
OFF state, is required to disconnect. In the 407B,
if the "Out of Service controlled by DTR" option
is in effect, placing DTR in the OFF state for
longer than 200 milliseconds will take the data set
out of service.

m. Data Set Ready, Lead 23 - From Data Set to Business
Machine: An ON condition on this circuit indicates
that the data set is either in the DATA mode and
is ready to receive data, transmit answer-back
signals, or both, depending on the condition of the
Data Receive lead (22), or is in the TALK mode.
An OFF condition will appear at all other times and
shall be an indication that the business machine
is to disregard signals appearing on any other
circuit in the interface, with the exception of the
Ring Indicator. When an OFF condition occurs during
the progress of a call before the Data Terminal

Ready lead is placed in the OFF state, the business machine should interpret this as a lost or an aborted connection and take action to terminate the call.

n. Signal Ground, Lead 24: This conductor establishes the common ground for those signals referenced to it. At the power supply, which serves a nest of eight data sets, this lead is brought to one point and connected to frame ground by means of a wire strap. This strap can be connected or removed at installation, as may be required to meet applicable regulations or to minimize the introduction or noise into electronic circuits.

o. Out of Service, Lead 25 - From Business Machine to Data Set: The presence of an ON condition on this lead will make the data set appear busy to incoming calls. In the EIA option, this lead is fail-safe to the ON condition. When an ACD is employed, this lead is not needed and should be OFF at all times. If the Out of Service controlled by DTR option is employed, this lead will be ignored by the 407B data set.

4. Call Handling Operation

Section 2.3 described two typical systems and briefly described the handling of calls in each. This section details operation of the 407 data set and referral switching equipment at the data base, including the exchange of interface signals with the business machine.

In switched service (DDD), Data Set 407 is designed to answer all incoming calls automatically. In this sense it always functions in an unattended mode (no manual answering is required unless DTR is operated manually). The call-handling procedure depends on whether a CALL DIRECTOR or an Automatic Call Distributor (ACD) is used in conjunction with the data set. The data set can also operate alone but, if a TALK mode is desired, a telephone set is required.

In private line service, the call-handling procedure is dependent on the customer's system operation.

4.1 Operation With CALL DIRECTORS

The serving central office indicates an incoming call by applying ringing to the line. In the 407A (or the 407B not in the computer down mode) the ringing signal is detected by the data set and is indicated to the data terminal by means of an ON condition of the RI lead. Data

Terminal Ready may already be ON, but if it is not, the
business machine must place it in the ON state in response
to RI ON to answer the call. With DTR ON, the set goes
off-hook, tripping ringing, and after a 1.5-second silent
interval it generates a 2025 Hz answer tone for 1.5 seconds.
As the call is answered, the lamp on the key telephone
associated with that line lights, indicating that the
connection has been made. Approximately 3 seconds after
ringing is tripped, DSR and DM go to the ON state to
indicate that the set is connected to the line and is in
the DATA mode. If Data Receive (DR) is ON, data
transmission can then take place until the call is
terminated. This sequence of events is depicted in the
timing diagram of Figure 6.

　　　If the set is in the DATA mode and the business
machine places the Attendant Request lead in the ON state
or, if the 407B is installed with the Terminal Initiated
Referral-Always option and the remote terminal sends the
TIR code (**), the button on the CALL DIRECTOR corresponding
to that line will flash at a rate of approximately 1 Hz,
indicating that a referral clerk should pick up the handset
and go into the TALK mode. The call is transferred to the
TALK mode by depressing the flashing button. Data cannot

be received from the remote location while the data set
is in the TALK mode (use of an ACD allows simultaneous
voice and data transmission - see Section 4.2). The DATA
Mode lead (lead 19) can be used by the business machine
to determine when the referral clerk has gone off-hook
following an Attendant Request. When the clerk does so,
the DATA Mode lead goes OFF and the business machine should
turn the AR lead OFF. The business machine may choose to
terminate the call if the referral clerk does not answer
the phone (DM does not go from ON to OFF) within a suitable
time period as determined by the system requirements. A
return to the DATA mode can later be accomplished at the
conclusion of the referral by depressing the DATA (HOLD)
button, in which case another answering sequence occurs
to indicate to the remote station that further data
transmission can take place. The sequence is the same as
the one after ringing is tripped in Figure 6.

The call is terminated when the calling station
hangs up and the business machine location is:

1. In the TALK mode and the handset is returned to the
   cradle.

2. In the DATA mode and the business machine turns OFF the Data Terminal Ready lead for a period of at least 50 milliseconds.

3. Using the 407B in the DATA mode and the hang up code (*#*) is detected.

Note: When using the 407A, the customer should employ some end-of-message code or character sequence suitable to his system to indicate to the business machine that the call should be terminated by placing DTR in the OFF state. An alternate method is to have the business machine initiate disconnect directly, such as after a voice answer-back is complete or by means of a time-out if no end-of-message is received from the remote location. When using the 407B, transmission of *#* will result in disconnection without any action by the business machine. In any case, the telephone central office should not be relied on for ending the call. While some central offices will open the line, causing disconnect, and others will disconnect by means of a time-out circuit, these are not universal features of central offices.

If in the "computer down" mode, the 407B will answer the call and send a 3.5-second answer tone regardless of the state of the DTR lead from the business machine. If the first character received (except *) does not contain the B_4 frequency, the data set will transmit a .5 Hz beeping tone to signal "computer down." If no attendant request signal (**) is received from the calling party within 15 seconds, the set will then hang up.

4.2 Operation with an Automatic Call Distributor

When a 2B or 3A Automatic Call Distributor (ACD) is used in place of CALL DIRECTORs, several additional functions are introduced into the system:

1. Concentration of incoming calls.

2. Indication back to the business machine of referral clerk line selection.

3. Ability to send data to the business machine when the referral clerk is on the line.

4. Ability to free the data set to handle other calls while the attendant completes the referral.

When a call is placed to the business machine through an ACD, ringing is detected by the ACD. This allows the ACD to hunt for an idle port (data set) that has DTR in the ON state, indicating that it is ready to

accept a call. Upon finding a port with DTR ON, the call
proceeds again as shown in the timing diagram of Figure 6,
beginning from the "ringing tripped" point on the diagram.
A ring indication is not given on lead 14 of the 407 data
set in this case.

When the Attendant Request lead is placed in the
ON state by the business machine or the 407B performs a
terminal initiated referral, the ACD searches for a nonbusy
referral clerk's line and, upon finding one, generates two
TOUCH-TONE digits and sends them back to the business
machine through the data set. These digits identify which
clerk's line has been selected.* If the ACD cannot find
an idle attendant position, it does nothing. In this case,
if the business machine initiated the referral, the AR
lead must be turned OFF and back ON periodically until and
idle trunk is found (as signified by reception of the two
TOUCH-TONE digits). If the 2-digit code is not received
within 2 seconds after the AR lead is turned ON, the AR

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* In the 3A ACD, operated in the split gate mode, one
   arrangement allows the transfer trunks of one split to
   be directed to the input trunks of another split. In
   this arrangement, the two TOUCH-TONE digits do not
   identify which clerk's line has been selected, out
   only that a nonbusy trunk has been found.

lead should be turned OFF for a minimum of 100 milliseconds and then turned ON again to reattempt the referral request. With the 407B, if the attendant request is originated by the reception of the TIR signal (**), the 407B will automatically control the cycling.

At the same time that the ACD sends the two TOUCH-TONE digits, it sends a signal to the referral clerk's telephone to cause ringing on this set. Once the digits have been sent, the business machine can cause the data set to remain on-line by turning OFF only the AR lead or it can place AR and DTR in the OFF condition, which causes the data set to be dropped from the line to receive other calls (by bringing DTR back on after an interval of at least 100 msec), while the referral clerk completes the original call. If the business machine were to place DTR in the OFF state before the digits were received, the call would be dropped prematurely. If DTR remains ON after the referral clerk has answered, the data set remains on-line and the referral clerk's line is bridged onto the original connection, so that data can be entered into the business machine during the course of the conversation. After the clerk hangs up, further data can be entered.

Note that no "TALK" mode exists when an ACD is employed. Since data can be received during the clerk's conversation, there is no need for the capability of transferring the set off-line and later bringing it back on-line. Once the data set has disconnected, no further data can be entered. Connection to a data set can then be reestablished only by redialing.

If the data set is not dropped from the line during the referral clerk's conversation, the call is terminated when the calling party and the referral clerk hang up and the business machine turns OFF the Data Terminal Ready lead for a minimum of 100 milliseconds. It is recommended that an end-of-message code be sent by the customer or referral clerk to the business machine to indicate when transmission has been completed.

When an ACD is employed, out of service is accomplished by placing DTR in the OFF state, thereby making that data set appear busy to the ACD. The ACD will then direct the call to the next idle data set. The OS lead should be OFF at all times when operating with an ACD.

"Computer down" operation of the 407B when working with an ACD is identical to the operation with a CALL

DIRECTOR except that when the call is referred, the data set is dropped from the call and made available to handle new incoming calls as soon as the ACD selects an attendant position. In the CALL DIRECTOR system, the data set cannot be dropped from the connection during referrals.

4.3 Private Line Operation

A private line can be employed to connect the 407 data set directly to the remote station. In this case the set is on-line as long as DTR is ON, and no calling procedure is required other than that provided by the customer's system. If DTR is kept ON permanently, data or voice can be received by the set from the remote location at any time. Similarly, answer-back signals can be transmitted by the business machine any time that the remote station is available for reception. The data set can be taken out of service by placing DTR in the OFF state. The OS lead is not used in private line operation and can be permanently OFF.

If a TALK capability is desired, a key telephone can be used with the data set. Operation in response to an ON condition of the Attendant Request lead would depend on the arrangement, and might simply be to bridge the telephone to the data line. This would allow data to be

entered when the referral clerk is on the line. The data
set would remain on-line after the clerk hangs up.

In general, private line operation requires the
customer's system to provide any needed signaling. With
private lines, there are no ringing signals provided and
the 2025 Hz recognition tone is not generated unless DTR
goes from OFF to ON. Usually some type of signal is
initially required so that the person at the remote end
knows that the data set and the customer terminal are on-
line. The customer can accomplish this by designating a
code of his choice that will cause the business machine
to activate the Tone Answer-Back (TAB) circuit. Hence,
if the person at the remote end enters this code and
receives the tone response he will know that DTR is ON and
data can be sent.

5. Interface Electrical Signal Characteristics

The signals on the regular interface for the 407-
type data set conform to the electrical characteristics
prescribed by Electronic Industries Association (EIA)
standard RS-232-C, but an installer option is available
that allow the interface to be used with many business
machines that employ a closure interface. Hence, the
electrical signal characteristics for the "regular"

interface and "contact equivalent" interface are somewhat
different and are discussed separately below.

5.1 Regular Interface - EIA RS-232-C Electrical
     Characteristics

All leads in the regular interface except the
Voice Answer-Back and the Voice Receive leads conform
electrically to the characteristics specified in EIA
Interface Standard RS-232-C. The Voice Answer-Back leads
are terminated within the data set in 600 ohms balanced
to ground. The Voice Receive leads provide a 600 ohms
balanced pair on which the line signals are passed to the
customer.

The characteristics of the regular interface leads
are summarized below:

Summary of Data Circuit Interface Terms

Binary State	ONE	ZERO
Signal Condition	Marking	Spacing
Voltage State	Negative	Positive

Summary of Control Circuit Interface Terms

Control Function	OFF	ON
Voltage State	Negative	Positive

5.2 Closure-Type Interface

An installer activated option is provided on 407 data sets that permits the interface to be used with many business machines that were designed to operate with a closure interface. The option modifies both the driver and terminator circuits of the 407.

The drivers of the 407 closure-type interface can be represented by an equivalent circuit of approximately 1000 ohms in series with a source of approximately ten volts. The source will be positive or negative to ground, depending on the sense of the output, positive indicating a closure and negative an open circuit. Thus, closure sensors in business machines which are the equivalent of 1000 ohms to a negative ten volts will see zero volts (simulating a closure) at the interface when the 407 driver source is positive, and will see negative ten volts (simulating an open) at the interface when the 407 driver source is negative (see Figure 7). The option modifies the drivers in such a way that closures and opens are simulated at the proper times.

The closure-type interface option causes the terminators of the 407 to interpret an open (high-impedance) to ground on the interface lead as an OFF condition and

a short (low-impedance) to ground as an ON condition, which
is the correct logic for a closure interface. To ensure
proper operation, the impedance or voltage conditions
specified in Section 5.2.1 must be met. Note that grounded
contact drivers will meet these requirements. If solid-
state closure devices are used, they must use a positive
polarity to ground.

The overall characteristics of the optional
interface correspond to a closure interface in the following
ways:

Summary of Data Circuit Interface Terms

Binary State	ONE	ZERO
Signal Condition	Marking	Spacing
Closure State	Closed	Open

Summary of Control Circuit Interface Terms

Control Function	OFF	ON
Closure State	Open	Closed

It should be remembered that, with the optional interface,
the "closed" and "open" states are only simulated and do
not mean that there is a metallic contact in the circuit.

CAUTION:

Some business machine closure terminators may be of type different from that shown in Figure 7, approximately 1000 ohms in series with a negative 10 volts, and the optional 407 drivers may not provide the correct output for these terminators. For instance, a "worst case" would exist where the terminator in the business machine is 1000 ohms in series with a positive ten volts, which when used in conjunction with the optional closure-type interface would cause an open to be simulated when a closure was intended and vice-versa. A more common occurrence may be that the impedance and voltage of the terminator are such that the business machine cannot distinguish between an "open" and a "closed" condition. Hence, when the closure terminator is not "typical," the customer must determine whether his business machine will make the correct interpretations. In some cases a conversion to standard EIA terminators (specified by RS-232-C) and use of the regular interface may be required.

5.2.1 Equivalent Circuits for Closure-Type Interface

The equivalent circuit for the 407-type closure interface driver shown in Figure 8 can be used for

calculations. Values in this figure and the conditions
which must be met at the interface are as follows:

RS is 909 ohms ±1 percent.

VS is between 7.5 and 12.5 volts for ON or ONE and is

between -7.5 and -12.5 volts for OFF or ZERO.

VI must be a value that the customer terminal recognizes

as ON or ONE when VS is 7.5 to 12.5 volts and as OFF

or ZERO when VS is -7.5 to -12.5 volts. Typically,

the values of VI would approximate 0 volts for ON or

ONE and -10 volts for OFF or ZERO. The maximum range

of VI should be ±15 volts.

Similarly, the customer must determine whether
his closure-type driver will deliver the proper interface
signal to the terminator in the 407. The equivalent circuit
of this terminator is shown in Figure 9. Values in this
figure and the conditions which must be met at the interface
are as follows:

RT is 2860 (4270 for the Out-of-Service lead (OS)) ohms

±5 percent

VT is a minimum of 3.0 (1.25 for OS) volts and a maximum

of 4.5 (1.75 for OS)

VI must be no more than 0.4 volt, but greater than -15 volts for an ON condition; and must be at least 2.0 volts (1.20 volts for OS), but less than 15.0 volts for an OFF condition.

If the equivalent circuit of the customer's driver is passive (such as for a metallic contact or a transistor switch), and its equivalent resistance is 250 ohms or less for an ON condition and 100,000 ohms or greater for an OFF condition, VI will meet the requirement just stated.

Note that the Cut of Service (OS) circuit has a different equivalent circuit and voltage specification. This is because, for the regular interface (but not for the closure interface), OS goes to an ON condition instead of an OFF as the other leads do during a failure mode. If uniform active drivers are desired, the minimum requirement of 2.0 volts for an OFF can be used for all termination leads. Also, the requirement for a passive equivalent circuit specified above applies uniformly to all leads.

6. Maintenance and Testing

The 407 data set has several features that allow the customer to detect data set malfunctions without assistance from the Telephone Company. Using the lamp

indications and the local test feature described in
Section 6.1, the customer can quickly determine whether
the 407 receiver is functioning properly. This allows
rapid trouble isolation and can reduce customer system
downtime. In addition, if an Automatic Call Distributor
(ACD) is employed, the recording of "bad calls" by the
customer could speed the location of malfunctions at ACD
installations (see Section 6.2).

6.1   407 Trouble Location

There are essentially three "stages" in the trouble
location procedure for the 407 data set: (1) lamp
indications, (2) local test, and (3) remote test.

6.1.1   Lamp Indications

The seven lamps associated with each data set
(see Section 1.4) have a certain "normal" operation. ON
conditions of the lamps give the following indications:

1. ON - Indicates presence of +5 volt supply at the
    data set.

2. TR - Indicates that the business machine has placed
    Data Terminal Ready (lead 22) in the ON condition
    and is prepared to accept calls. The TR lamp is
    also on in the "computer down" mode.

3. RI - Indicates that ringing is being applied to the data set.

4. MR - Indicates that the data set has placed Data Set Ready (lead 23) in the ON condition. This lamp comes on 3 seconds after ringing is tripped if the data set is in the DATA mode and DTR is ON. Once DSR comes ON, it stays ON until the termination of the call, whether the set is in the TALK or the DATA mode.

5. DP - Indicates that the data set is receiving a signal which it interprets as a valid data character. Such reception can take place only when: (a) the set is in the DATA mode, (b) DSR is ON, and (c) the terminal has placed Data Receive (lead 21) in the ON condition.

6. AR - Indicates that a referral clerk has been requested.

7. OS - Indicates that the data set is put out of service by one of the following conditions:*

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* Note: Two other conditions can occur in which an out-of-service indication will be given to the ACD or central office, but the OS light will not light.
This will occur if:

    a. Power is lost to the data set.
    b. The data set is not plugged into the nest correctly or has been removed from the nest.

a. Out of Service (lead 25) is placed in the ON
    state by the business machine. (In the 407B,
    the Out of Service controlled by OS option must
    be selected for this action to cause the out
    of service condition.)

b. In the 407B with the Out of Service controlled
    by DTR option selected, the DTR lead is placed
    in the OFF state by the business machine.

c. The data set is under test.

d. The connector to the business machine is not
    plugged in correctly. (With the closure inter-
    face option and out of service not controlled
    by DTR, OS will be OFF for this condition.)

The above list indicates the order in which the
lamps are located on each data set and also is the order
in which the lamps usually come on when a call is received.
RI and DP are flashing when they are ON, AR may come on
steadily or flash, all the others are either steady ON or
OFF. When the lamps do not come on at the appropriate
times listed above, the "lamp test" switch should be
depressed to activate all the lights in the cabinet to
ensure that they are in proper working order. If the lamp

is not faulty, abnormal lamp operation indicates there is
probably a malfunction in the data set which should be
reported to the Telephone Company to initiate repairs.

6.1.2 Local Test

The local test is performed by the customer or
by Telephone Company personnel to obtain a rapid checkout
of the data set receiver circuitry. The procedure for
performing the local test is shown on decals on the data
mounting cover and is as follows:

1. Remove the interface plug and cord from the set to
   be tested and replace them with the cord from the
   test unit. This places the set in the "TEST" mode.

2. Place the test switch in the "LOCAL Test" position.
   Approximately 3 seconds later the "LOCAL Test" lamp
   should come on.

3. Using the TOUCH-TONE pad on the test unit, depress
   each TOUCH-TONE key to see whether the lights at
   the ends of the corresponding row and column flash.*
   Flashing indicates that the signal has been detected
   by the receiver properly.

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* In the 407B data set, the AR lamp will light or flash
  when the * key is depressed, if the Terminal Initiated
  Referral-Always option is installed.

4. If some lights do not flash properly and the lamp
    test indicates that all the lights are in proper
    working order, there is trouble in the receiver
    circuitry and the Telephone Company should be called
    for repairs.

5. If all the lights operate properly but the circuit
    still does not function, verify that the business
    machine is operating properly. If the trouble still
    cannot be traced to any other part of the system,
    call the Telephone Company to obtain a remote test.

6.1.3 Remote Test

The remote test is performed from a Telephone
Company test center, and it allows a more thorough checkout
of the data set. The line control circuitry not included
in the local test can be checked along with parameters
such as sensitivity and bandwidth. To activate the remote
test, the test switch must be placed in the "REMOTE Test"
position and the test cord must be connected to the data
set under test as in Step 1 above. This links the data
set to the telephone office via a separate service line.
The "REMOTE Test" lamp on the test set will come ON three
seconds after the test call is answered and will remain
lighted while the remote test is in progress. At the end

of the test procedure, the "REMOTE Test" lamp will go off
and the test cord can be removed.

During both the local and the remote tests the
incoming line is "made busy" so that, when the central
office or an ACD is hunting for an idle port, it will skip
over the line under test.

A "remote test" can also be performed by the
customer simply by calling the service line from another
TOUCH-TONE phone. The cable from the test unit must be
plugged into the set to be tested, and the test switch
must be in the "REMOTE Test" position. This allows a
checkout of the line control circuitry (by listening for
the 2025 Hz answer tone) and the receiver circuitry (by
watching the DP light as data is keyed in), but it doesn't
allow measurement of specific parameters.

6.2 Trouble Location at ACD Installations

Because of the random assignment of lines to data
sets by an ACD, it may be difficult to tell whether a
continuing malfunction is in the incoming line, the ACD,
or the data set without some pertinent statistics on the
malfunction. Hence, it would speed trouble location if
the customer's computer could record the following for
each port:

1. Number of incoming calls (number of times DSR comes ON).

2. Number of calls in which DSR came ON but no data was received (DP not activated).

3. Number of calls in which no normal end-of-message transmission was received, but DSR was turned OFF.

These statistics could then be reported to the Telephone Company at the same time the malfunction is reported, so that the trouble could be cleared more rapidly.

7. Performance

Various parameters in the data transmission system contribute to the performance of 407-type data sets. Two of these, frequency and amplitude variations, are the result of manufacturing and alignment tolerances in the transmitters as well as variations introduced by the transmission facility. Due to the nature of the detection process and the relatively slow data rate of ten characters per second (max.) some transmission facility parameters such as phase hits, phase intercept distortion, and envelope delay distortion have a negligible effect on the performance of the receiver. Dropouts also have a negligible effect due primarily to their relatively infrequent occurrence, but also to the fact that the TOUCH-TONE signal format is

in an OFF, or dropout, condition approximately 50 percent
of the time and short term dropouts occurring during these
OFF periods are completely ignored.

Gain hits are of minor importance because those
that have sufficient amplitude to cause an error occur
infrequently and they do not contribute substantially to
the overall error rate.

Those parameters that are of importance to the
successful operation of 407-type data sets are attenuation
distortion, loss, C-message noise, impulse noise, and
frequency deviation.* The effect of these parameters on
the error performance of 407-type data sets has been
determined by extensive, controlled, laboratory tests.
The results of the tests, together with the results of the
1969-70 Connection Survey, indicate that an error rate
objective of less than one error in 10^5 characters
transmitted can be achieved on approximately 91 percent
of all connections. The predominant cause of those errors
that do occur is impulse noise.

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* Here attenuation distortion is used to mean the relative
  amplitude of the low and high frequency tones making up the
  received TOUCH-TONE signal, and frequency deviation means the
  net departure from nominal of each received TOUCH-TONE
  frequency. These impairments are due to the combined effect
  of variations caused by the transmission facilities and
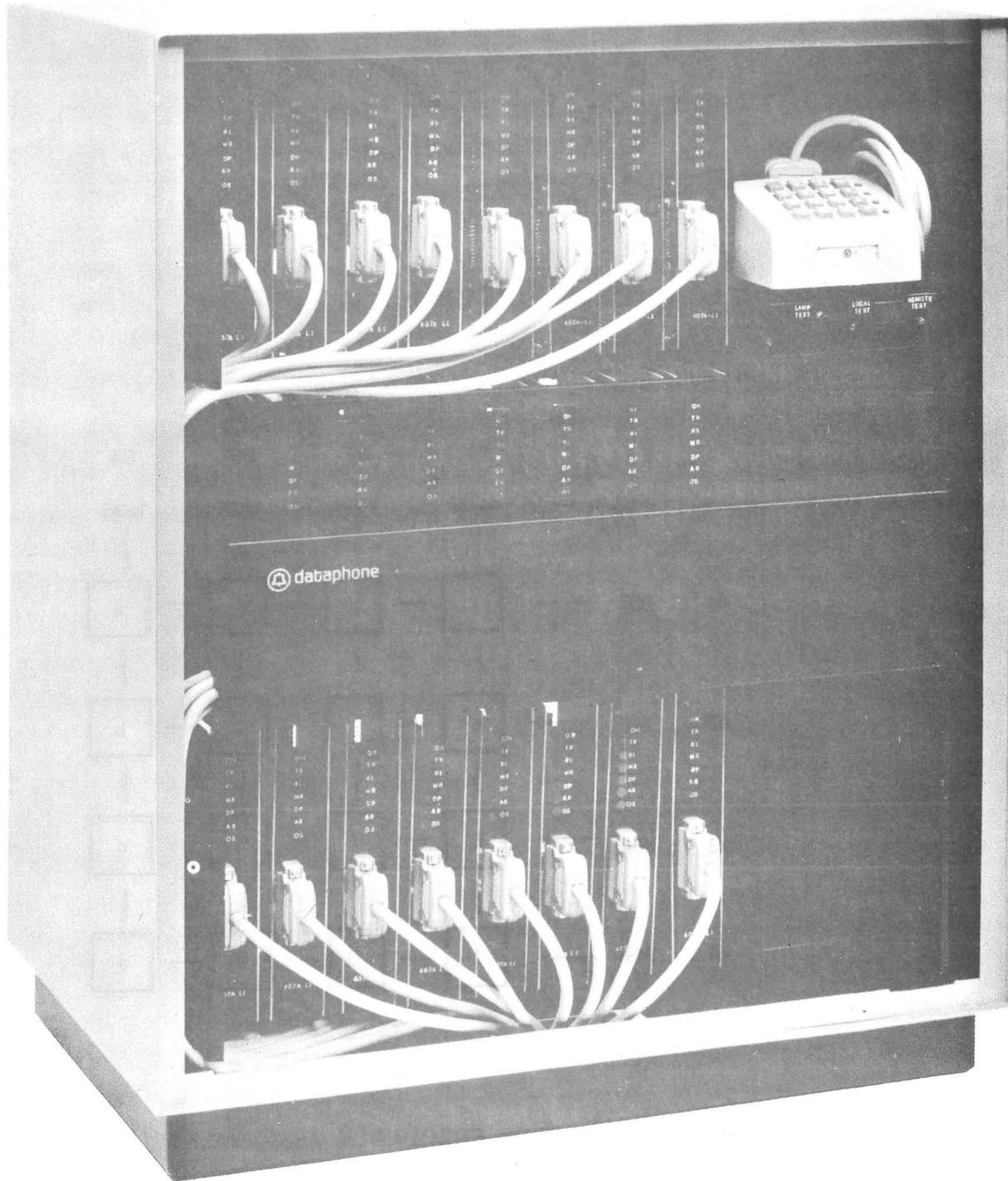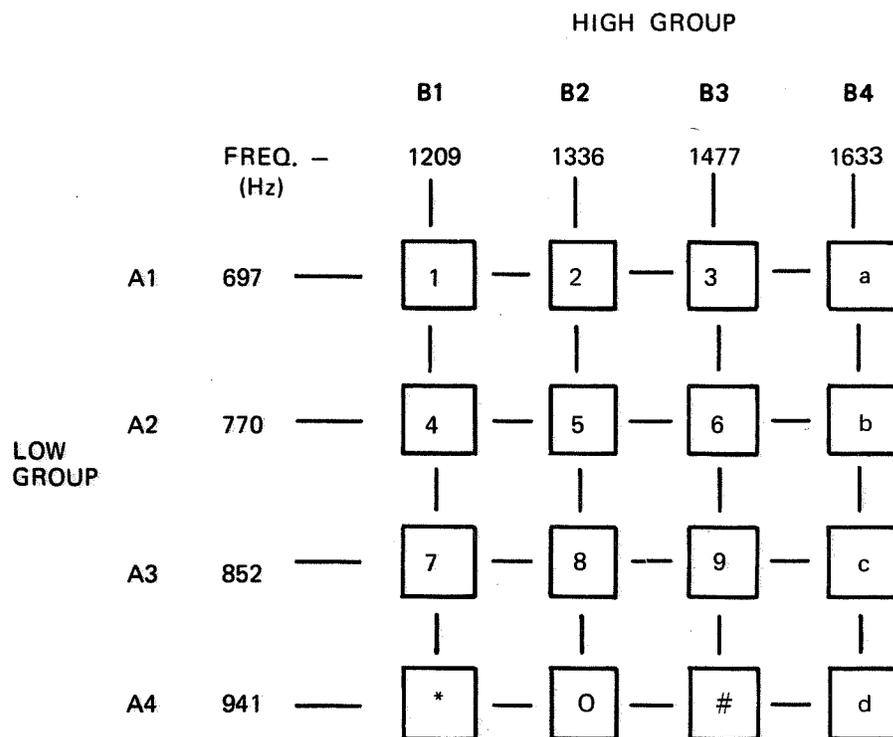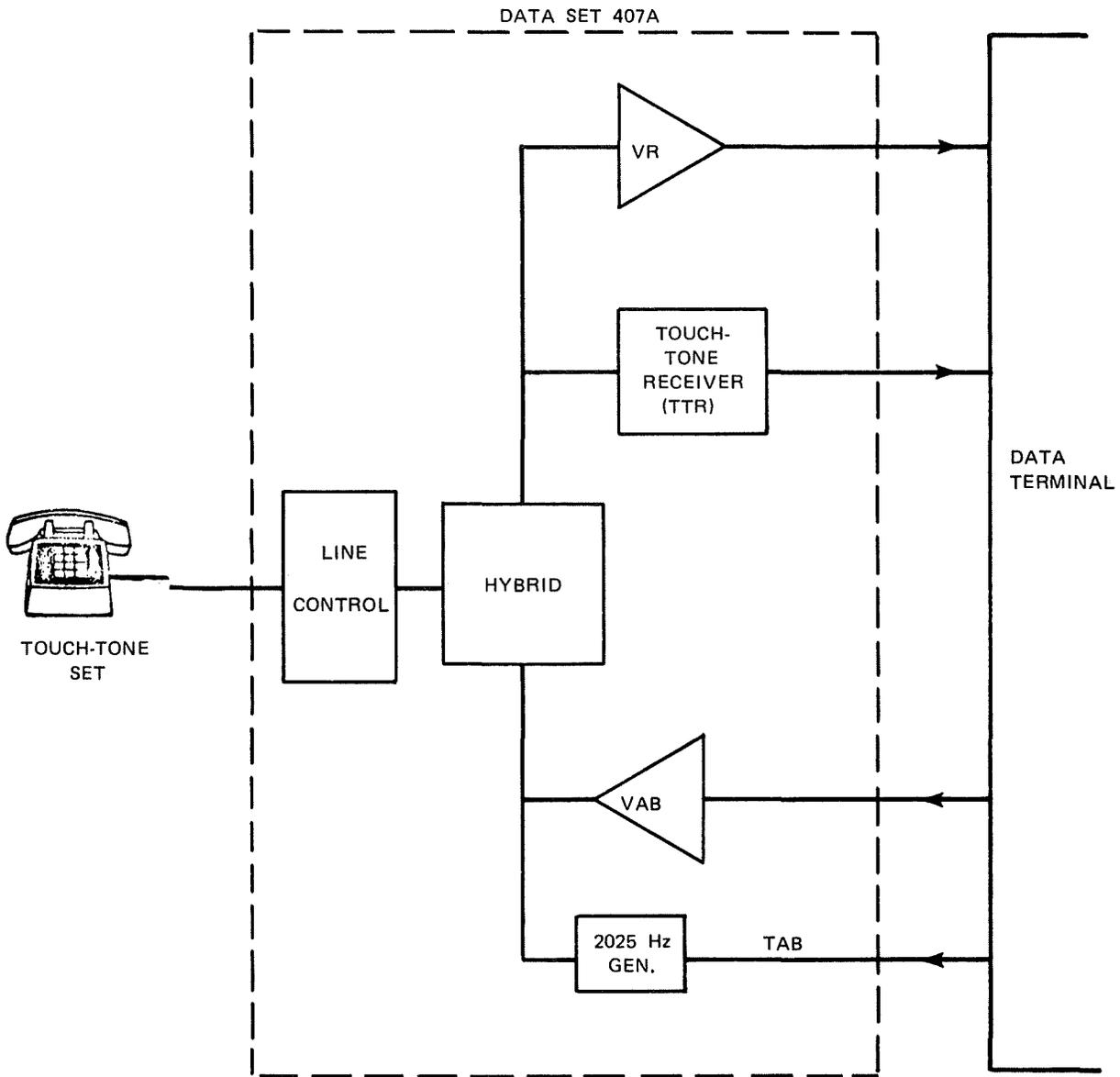 manufacturing tolerances in the transmitter.

FIGURE 1 - FRONT VIEW OF 407 MULTILINE INSTALLATION,
FULLY EQUIPPED

NOTE: Covers have been removed from top
and bottom data mountings to show
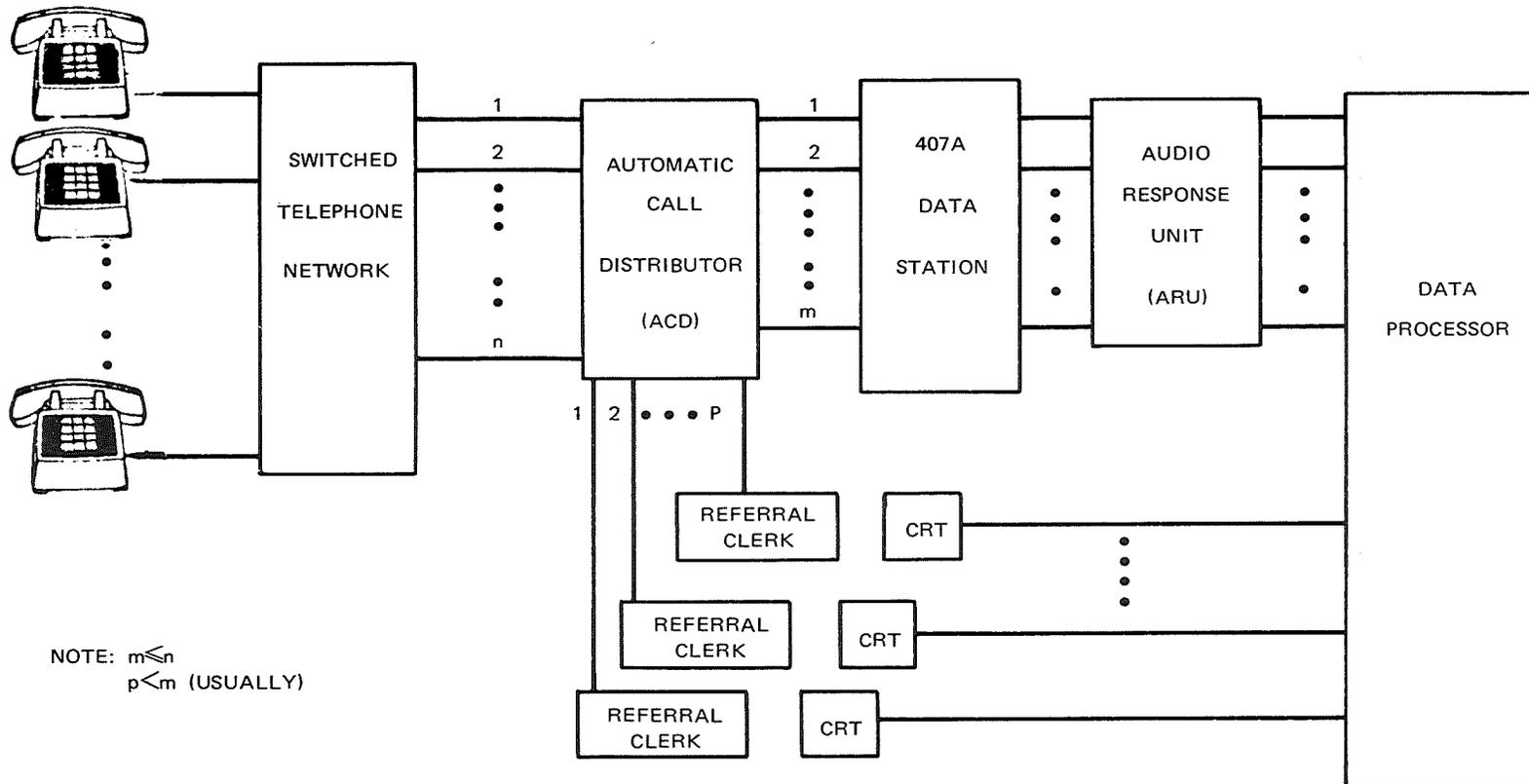customer interface connectors and
cables.

HIGH GROUP

| | | B1 | B2 | B3 | B4 |

FREQ. —
(Hz)

1209   1336   1477   1633

			B1	B2	B3	B4
A1	697	1	2	3	a
A2	770	4	5	6	b
A3	852	7	8	9	c
A4	941	*	O	#	d

LOW
GROUP

TOUCH-TONE DIAL WITH FREQUENCY ASSIGNMENTS
FIGURE 2

DATA SET 407A

VR

TOUCH-
TONE
RECEIVER
(TTR)

LINE
CONTROL

HYBRID

DATA
TERMINAL

TOUCH-TONE
SET

VAB

2025 Hz
GEN.

TAB

VR — VOICE RECEIVE
VAB — VOICE ANSWERBACK
TAB — TONE ANSWERBACK

RECEIVE AND ANSWERBACK FUNCTIONS OF 407A
FIGURE 3

SWITCHED
TELEPHONE
NETWORK

1
2
•
•
•
•
n

AUTOMATIC
CALL
DISTRIBUTOR
(ACD)

1
2
•
•
•
•
m

407A
DATA
STATION

AUDIO
RESPONSE
UNIT
(ARU)

DATA
PROCESSOR

1 2 • • • P

REFERRAL
CLERK

CRT

REFERRAL
CLERK

CRT

REFERRAL
CLERK

CRT

NOTE: $m \leqslant n$
$p < m$ (USUALLY)

TYPICAL CREDIT   CHECK SYSTEM
FIGURE 4

TRANSACTION Telephones

SWITCHED
NETWORK

407B
DATA
STATION

AUDIO
RESPONSE
UNIT

CUSTOMER
COMPUTER
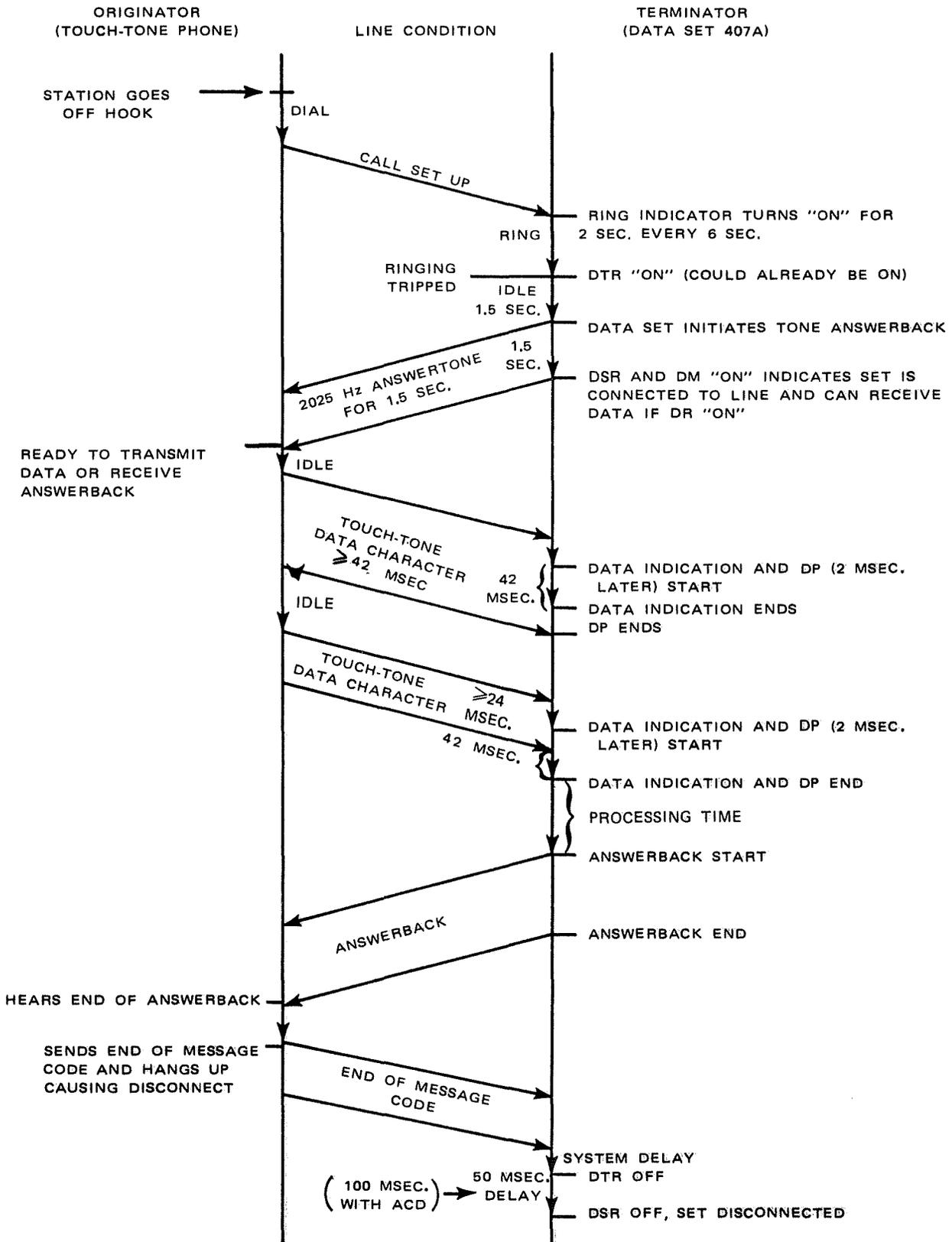
REFERRAL
CLERK
POSITIONS
EQUIPPED
WITH CALLS
DIRECTORS
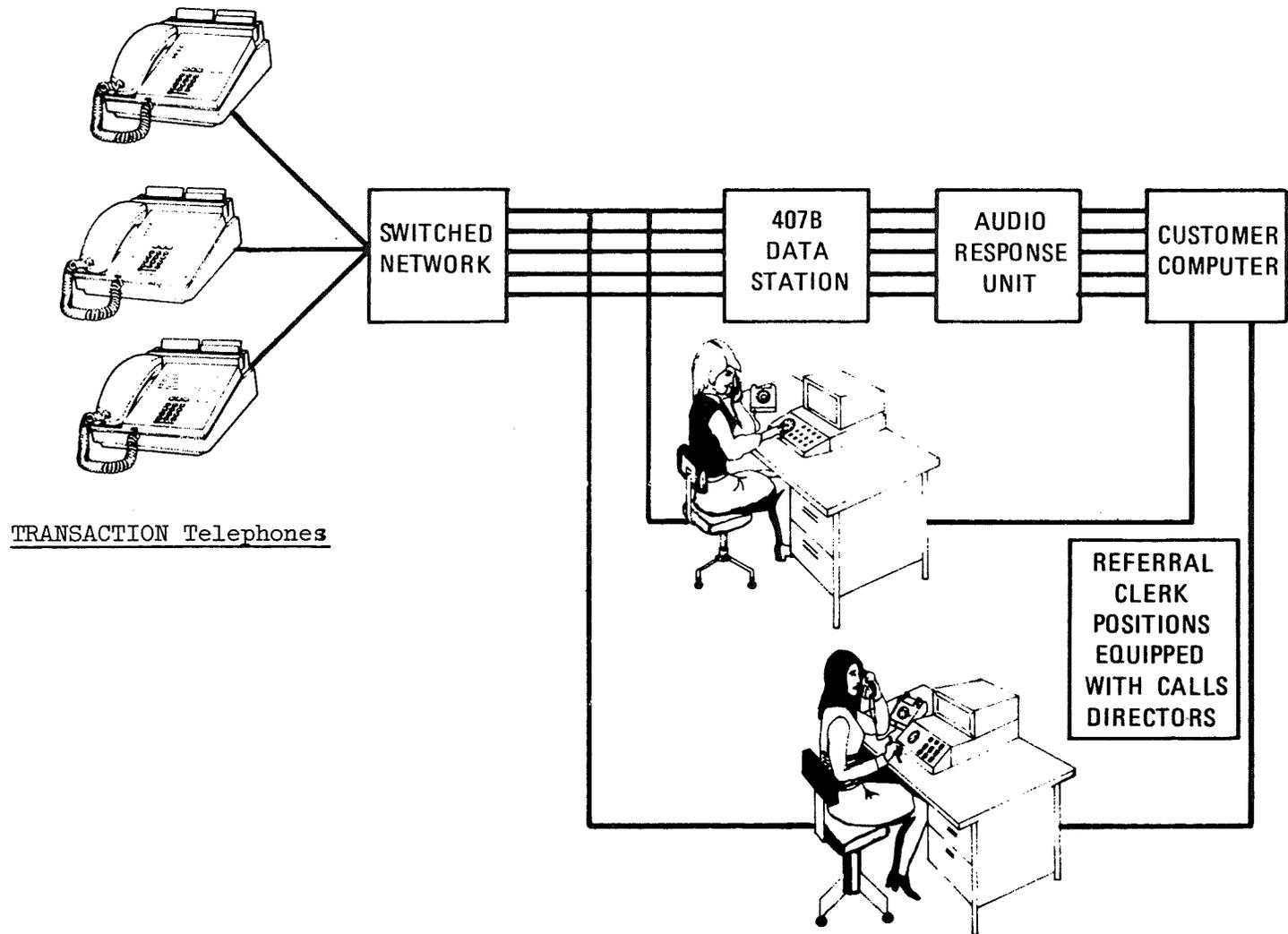
Typical TOUCH-TONE Data System

Figure 4B
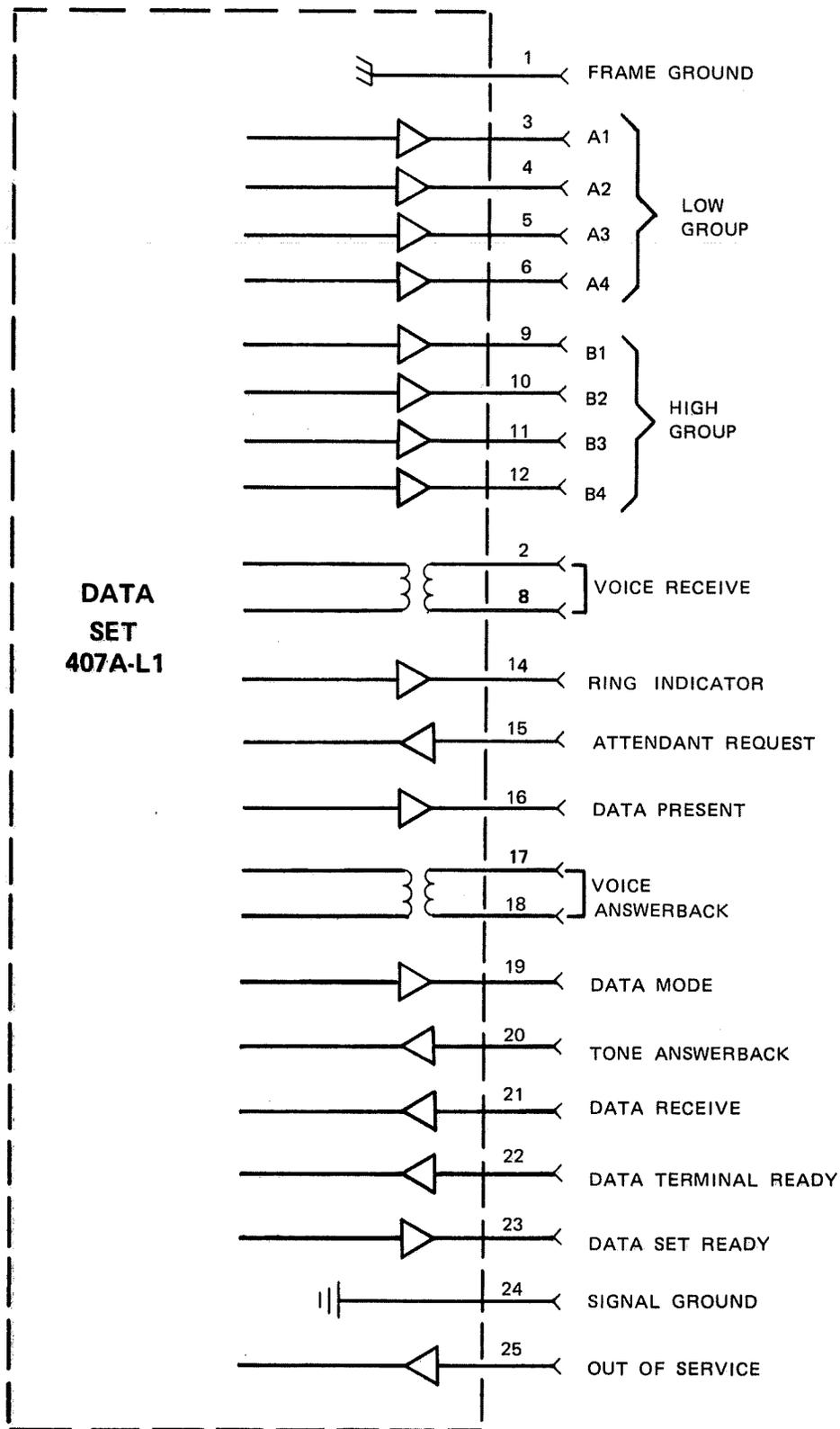
DATA SET 407A-L1 INTERFACE
FIGURE 5

TIMING DIAGRAM
FIGURE 6

| 407 VOLTAGE DRIVER | CUSTOMER TERMINAL (CLOSURE SENSOR) |

$E_s = +\ 10V$

≈ 1000 I_I 1000
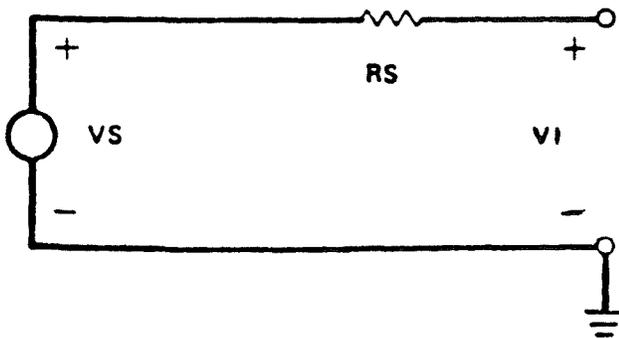
E_I

$E_s = -10V$

$-10V$
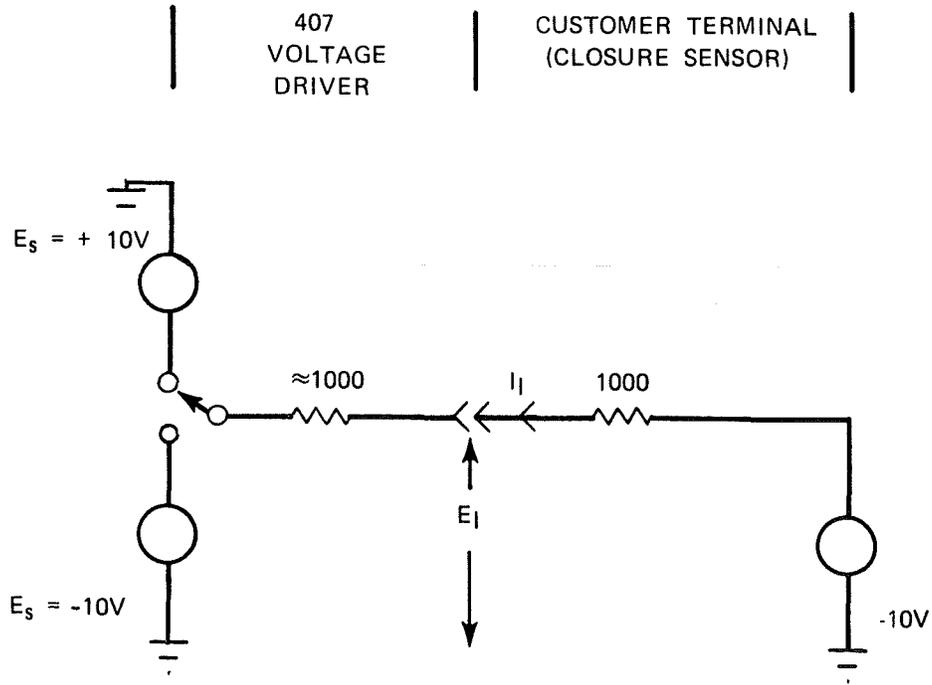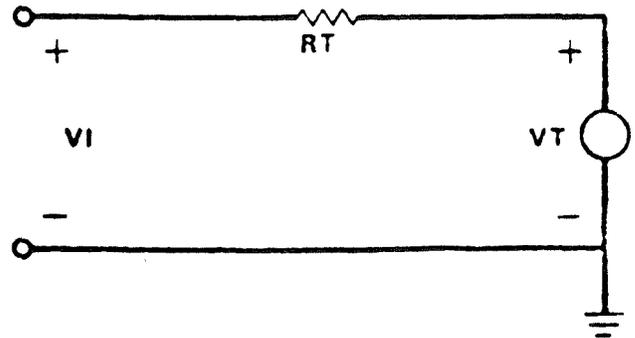
$E_s = +10V - E_I \approx 0,\ I_I$ NON ZERO,
                    SIMULATES A CLOSURE

$E_s = -10V - E_I = -10V,\ I_I = 0,$
                    SIMULATES AN OPEN

OPERATION OF 407A VOLTAGE DRIVER CIRCUIT WITH A CLOSURE TERMINATOR
FIGURE 7

+	RS	+
VS		VI
−		−

+	RT	+
VI		VT
−		−

FIGURE 8
Equivalent Circuit of 407
Closure-Type Interface Driver

FIGURE 9
Equivalent Circuit of 407
Closure-Type Interface Terminator

Appendix A

Glossary of Terms

Audio Response Unit (ARU) - A customer-provided device that puts out recorded or synthesized voice messages upon command from the customer business machine.

Automatic Call Distributor (ACD) - A device that concentrates incoming calls by hunting for an idle data set each time a new call comes in. This increases line and data set usage efficiencies.

Binary Coded Matrix (BCM) Interface - An optional interface for Data Set 403 that transfers data by means of binary indications on four interface leads.

Business Machine - The customer-provided device that gives digital information to the data set at the transmitting end and accepts digital information from the data set at the receiving end.

Closure-type Interface - Interface structure in which one signaling state is indicated by a low resistance (closure) at the interface terminals and the other state by a high resistance (open).

DATA Mode - A condition in which the data set is on-line and active (not in TEST, TALK, or IDLE mode).

Data Set - A device that either transforms digital information into a form suitable for transmission over analog transmission lines or puts the information back into digital form at the receiving end of the line, or both.

Digit Simulation - A situation in which a receiver interprets part of a received signal as a valid character when in fact no digital character was transmitted.

DSR - Data Set Ready - Interface lead that indicates the operative state of the data set. See paragraph m of Section 3.

DTR - Data Terminal Ready - Interface lead that indicates the operative state of the customer terminal. See paragraph d of Section 3.

Modem - A contraction of modulator-demodulator; another term for data set.

Parallel Data Transmission - Method of data transmission in which the customer terminal sends and receives two or more bits (ONEs and ZEROs) simultaneously.

Referral Clerk - In an inquiry/response system, a person who handles the call when the business machine is unable to resolve the call automatically.

TALK Mode - For Data Set 407-type, a condition in which the data set is transferred off-line and a voice connection is established between a referral clerk and the originating party. The data set can later be transferred back on-line if desired.

Two-out-of-Eight - A coding scheme in which one frequency is chosen from each of two 4-frequency groups to represent a single character. This gives 16 possible combinations of characters.

Appendix B

List of Related Bell System Technical References

1. "Data Sets 401A and 401E Interface Specification" - April 1966 (PUB 41401).

2. "Data Set 401J Interface Specification" - September 1965 (PUB 41403).

3. "Data Sets 403D, 403E Interface Specification" - November 1967 (PUB 41406).

4. "Data Communications Using the Switched Telecommunications Network" - May 1971 (PUB 41005).

5. "1969-70 Switched Telecommunications Network Connection Survey" (Reprints of Bell System Technical Journal Articles) - April 1971 (PUB 41007).

6. "Data Communications Using Voiceband Private Line Channels - (PUB 41004).

7. "Switched Network TRANSACTION* Telephone System" - (PUB 41804).